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Marking Substances and Security Markings and Method of Their Integration in Paper Pulp Lines and Method of Testing

The invention relates to marking substances and security markings and to a method of integrating them into the paper pulp line of documents, securities, bank notes, wrappings and products, as well as to a method of testing electrically conductive marking substances and security markings integrated in this manner, in accordance with the preambles of claims 1, 13, 32 and 53.

To raise the level of certainty against counterfeiting, paper pulp lines of documents, securities, bank notes, wrappings and of products are provided with marking substances. Light-activated marking substances hitherto used are at present available in the market, so that counter fitters are in a position to falsify security elements fabricated with them.

With a view to setting up hurdles against this situation for counter fitters complicated solutions have been devised using light-activated marking substances in which, as described in German patent specification DE 196 53 423, light absorbing substances invisible to humans are additionally used. In this manner printed images with noticeable error sections are generated during testing using infra-red light.

Furthermore, to improve the certainty against counterfeiting, marking substances are applied in a predetermined distribution to a web of paper to render their authenticity machine-readable. In accordance with DE 197 14 519 substances not visible by humans are used for this purpose, which are superimposed as a linearly designed markings on a visible printed image. Because of its physical property the marking substance is supposedly detectable by a machine. Electrical conductivity is mentioned, among others, as one of the physical properties; however, there is no teaching of any

Replaced by Article 34

marking substance which is invisible to the human eye.

A security element currently commonly used in bank notes is embodied in a foil structure consisting at least of a support foil and a metallization applied to the support foil. A so-called security thread is embedded, either completely or with windows (interruptions), into the paper web. Originally, such a safety thread including recognizable demetallized sections shaped as symbols or letters served only for visual testing by humans. In attempting to improve the certainty against counterfeiting it was considered additionally to test the electrical conductivity of the metallization. Until now, the realization of such attempts has on the one hand been frustrated not only by the high mechanical use suffered by bank notes, for instance, by creasing and folding by a user, but also by bending in automatic teller machines and counting machines. On the other hand, the foil structure is already subjected to considerable stress, because of tension and bending, during the technological process of manufacturing the paper. As a result, there will occur in the metallization randomly distributed fine hairline fractures which render any test result uncertain and not reproducible. However, to act against counterfeiting of these security elements, it is not only necessary to prove the presence of a metallization in bank notes, but authenticity must be recognized on the basis of measuring a certain conductivity value. In principle, this problem is not solved by using metallically acting printing inks instead of vapor deposited metallizations, as proposed by DE 43 44 553 and EP 0 659 587.

Since electrical conductivity is one of the essential properties of metals, it seems to be obvious that counter fitters will assume the electrical conductivity of a metallization. In fact, technological equipment is currently readily available for inserting actual metallizations including their image-like designs as counterfeits of a security element into documents, securities, bank notes, wrappings or products. However, since electrical conductivity is a

testing parameter which can be detected quickly and with certainty, no desire exists at present to do away with this security element. It is an additional disadvantage that the properties of the metallization which is visible to the human eye are substantially constant as for the majority of users it is to serve as a constant security element always recognizable as such. Finally, a relatively large number of persons are familiar, in connection with its fabrication and testing, with the secrets of this humanly recognizable security element, so that the size and unsurvaillability of this group of persons introduces a further risk potential.

It is, therefore, an object of the invention to propose electrically conductive marking substances and methods of their integration into the paper pulp line of documents, securities, bank notes, wrappings and products in which the disadvantages mentioned above do not occur. It is a further object of the invention to propose marking substances of the kind which contribute to improving the certainty against counterfeiting because the necessity has arisen for providing a further easily variable security element which draws less attention to itself than does the visually recognizable metallization, or to propose a security element at different positions where it is not expected and where it can be detected only by testing technology operating with extreme precision. These security-serving characteristics and elements are integrated into the paper pulp line either directly or in connection with other security elements included in the paper pulp line, such as safety threads. Finally, it is an object of the invention to propose a method of testing electrically conductive marking substances integrated in this manner.

In accordance with the invention, the object is accomplished by the characteristics and elements of claims 1, 13, 32, and 53 as well as their specific embodiments defined in the sub-claims. Aside from the claims, the characteristics of the invention are also apparent from the description and the drawings, the characteristics constituting protectable embodiments either by

themselves or in several sub-combinations, for which protection is sought.

The solution in accordance with the invention provides the advantage, in connection with safety paper, of furnishing marking substances and safety elements with hidden detectable elements which cannot be recognized by human vision and the homogeneous or partial presence of which is to be tested. Surprisingly, at the same time, the advantage of a continuously operating, time-saving and cost-efficient method of introducing marking substances and safety elements into paper pulp lines also results.

The invention will be described on the basis of the following examples and of the figures.

Fig. 1 is a schematic side elevational view and top elevational view of a long strainer of a paper making machine for depicting the method of the partial integration of the marking substance in a linear configuration;

Fig. 2 is a schematic side elevational view and top elevational view of a round strainer of a paper making machine for depicting the same method;

Fig. 3 is a schematic side elevational view of a round strainer with a connected water mark embossing roller;

Fig. 3a is a schematic top elevational view of a sheet during testing including a signal graph of a sheet provided with a homogeneously integrated marking substance and embossed water mark;

Fig.4 is a schematic side elevational view of a round strainer of a

paper making machine with pulp intake for the homogeneous integration of the marking substance;

Fig. 5 is a schematic side elevational view of a long strainer of a paper making machine with pulp intake for the homogeneous integration of the marking substance;

Fig. 6 is a graph of a signal generated when sweeping a sensor over a bank note with a homogeneous distribution of marking substance and a security thread;

Fig. 7 is a graph of a signal generated when sweeping a sensor over a bank note with a homogeneous distribution of marking substance and a water mark;

Fig. 7a depicts the combining of sensor signals;

Fig. 8 is a schematic side elevational view of a water mark embossing roller with a marking substance transfer roller;

Fig. 8a is a graph of a signal of an electrically conductive water mark in conventional paper;

Fig. 9 is a schematic presentation during partial application of marking substance onto or integration of marking substance into the paper pulp line;

Fig. 10 depicts graphs of signals of the detection of partial marking substance;

Fig. 11 depicts a foil structure with a support foil, a metallization and a

further layer of an electrically conductive polymer;

Fig. 12 depicts another foil structure with a support foil, a metallization and a further layer of an electrically conductive polymer;

Fig. 13 depicts a foil structure made of two support foils and a metallization, each support foil supporting a further layer of an electrically conductive polymer;

Fig. 14 depicts a foil structure made of two support foils, a metallization and a further layer of an electrically conductive polymer.

In Fig. 1, there is depicted a paper making machine in schematic side and top elevational views, with a long strainer 1, a pulp applicator 3, output tubes 17, a control unit 18 for the output tubes 17, an automatic valve 19 in each output tube 17, a pump 20 for the circulation of marking substance and a supply vessel 26 for the marking substance for partial integration. Furthermore, test zones 14 containing marking substance are shown.

Fig. 2 depicts a round strainer 2 of a paper making machine in schematic side and top elevational views with a pulp input 4, partial test zones 14, output tube 17, control unit 18 for the output tubes 17, automatic valve 19 in each output tube 17, the pump 20 for the circulation of marking substance and the supply vessel 26 for the marking substance for partial integration.

Fig. 3 is a schematic view of the round strainer 2 of a paper making machine with a connected water mark embossing roller 5, the marking substance homogeneously distributed in the paper 6, the pulp input 4 and the embossing segment 25 of the water mark embossing roller 5.

Fig. 3a is a schematic top elevational view of a sheet during testing, including the signal graph 23 of the sheet with homogeneously integrated marking substance and embossed water mark and with optical sensors 13 for activating a plurality of capacitive scanning sensors 11. A schematic time scale with time indicia 1 - 16 is depicted below the sheet. The signal graph depicts the voltage U of the capacitive scanning sensors 11 as a function of the time of time indicia 10 - 13..

Fig. 4 depicts the round strainer 2 of a paper making machine in schematic side elevation, with a pulp input 4 for the homogeneous integration of the marking substance and with a vat 8 of the machine.

Fig. 5 depicts the long strainer 1 of a paper making machine in schematic side elevation, with a pulp input 3, a machine vat 8 and the marking substance homogeneously distributed in the paper.

Fig. 6 depicts the signal graph 23 of U = f(t) when sweeping the scanning sensors 11 over a bank note with homogeneously distributed marking substance and with a security thread 15, and the optical sensors 13 for activating the capacitive scanning sensors 11.

Fig. 7 depicts the signal graph as a diagram of voltage U as a function of the number of channels when sweeping the optical scanner sensors 10 and the capacitive scanning sensors 11 over a bank note with homogeneously distributed marking substance 6 and with an electrically conductive embossed section 24. The sensor channels 1 - 14 are depicted schematically.

Fig. 7a depicts the signal combining of the optical scanning sensors 10, of the capacitive scanning sensors 11 and of the optical sensors 13 for actuating the capacitive scanning sensors 11 during testing of a sheet

provided with partial test zones 14.

Fig. 8 is a schematic side elevational view of a water mark embossing roller 5 having embossing segments 25 and with a marking substance transfer roller 7, an electrically conductive test zone 9 structured as a water mark, a supply vessel 16 for marking substance and a pressure roller 27.

Fig. 8a depicts the signal graph as a diagram of voltage U as a function of the number of channels during testing of an electrically conductive test zone 9 in paper not provided with marking substance.

Fig. 9 is a schematic presentation of testing with the capacitive scanning sensors 11 following partial integration of marking substance into the paper pulp line according to Fig. 8, the optical sensors 13 for activating the capacitive sensors and with different partial test zones 14a, 14b, 14c.

Fig. 10 depicts signal graphs 23 of the partial marking substance detection according to the arrangements in Fig. 9.

Fig. 11 depicts a foil structure consisting of a support foil 28, a metallization 29 and a further layer 30 of an electrically conductive polymer.

Fig. 12 depicts another foil structure consisting of a support foil 28, a metallization 29 and a further layer 30 of an electrically conductive polymer.

Fig. 13 depicts a foil structure consisting of two support foils 28; 28' and a metallization 29, each support foil 28, 28' carrying a further layer of an electrically conductive polymer.

Fig. 14 depicts a foil structure consisting of two support foils 28, 28', a metallization 29 and a further layer 30 of an electrically conductive polymer.

Example 1:

Figs. 1 and 2 depict the manner in which a partial application of a marking substance is being accomplished by metering devices positioned precisely over the paper pulp line 6. The precondition for a homogeneous supply of the metering devices with marking substance is a continuous circulation of the paper pulp by pumps 20 in the entire tubular system including the supply vessel 26 of the marking substance to be partially integrated. The marking substance is partially applied to, or integrated into, the paper pulp line by an array of metering devices each consisting of an output tube 17 with an automatic valve 19. This leads to the formation, in dependence of the control, linear continuous test zones 14a, discontinuous test zones 14b or doted test zones 14c. See also Fig. 9. By cutting the paper pulp line into sheets partial test zones 14 with marking substance result. These may extend over the entire width or length of the sheet, or they may be present as sections over the length or width of the sheet. The width of the lines or line sections must by adjusted to the resolution of the scanning sensors 10; 11. Preferably, the width of the line is chosen to be 2 mm.

Figs. 4 and 5 depict the preparation of paper pulp homogeneously blended with marking substance or the fabrication of special paper with electrically conductive polymers or electrically conductive pigments in connection with a long strainer 1 and a round strainer 2. For this purpose the paper pulp is blended with marking substance in the machine vat 8 and is maintained in a state of homogeneous suspension by constant stirring. In case of a solid marking substance the amount added is preferably 10%. The amount may vary depending on the type of detection.

The use of electrically conductive polymers results in the advantage that these polymers are compatible with the other contents of the paper pulp. The integration into the paper pulp is thus substantially less complicated than

it is in the case of solid marking substances since electrically conductive polymers are available in liquid state. The required concentrations make possible a substantially transparent electrically conductive marking.

Example 2:

Two further possibilities of integrating a marking substance into the paper pulp line 6 are shown in Figs. 3 and 8. In this case, a code is fabricated by a change in the density of the substance of the otherwise homogeneously distributed marking substance. This is accomplished by embossing in the embossing area 24, which leads to a change in the density of the substance and, hence, in a change of the electric conductivity.

The other possibility is a partial application of the marking substance. To this end, an imprint is formed on the paper pulp line by the embossing roller 5 and the marking substance transfer roller 7. The imprint of the embossing segments 25 corresponds to the pictorial image of the electrically conductive test zone structured as the water mark 9.

Example 3:

Aside from the method of integrating marking substance, Figs. 1 and 2 also depict that the test zones 14 in the paper pulp line 6 are tested for the partial or homogeneous presence of marking substance. The test result derived therefrom affects, by way of the control unit 18, the automatic valves 19 in the output tubes 17.

As has already been mentioned, Figs. 3a, 6, 7, 7a, 8a, 9 and 10 depict the test method in different applications, with corresponding signal graphs.

The method of testing paper 6 with integrated electrically conductive

marking substance structured, for instance, as an electrically conductive polymer, will hereafter be described with reference to Fig. 3a. As schematically shown, the paper 6 with an embossed water mark traverses an array of optical sensors 13. These activate a further array of capacitive scanning sensors 11 extending across the entire width of the paper pulp line 6. The time scale with time indicia 1-16 renders an indication of the time during which the paper 6 moves through the arrays of the optical sensors 13 and the capacitive sensors 11. While the paper 6 is moving, the capacitive sensors 11 generate a voltage corresponding to changes in the electrical conductivity of the paper pulp line 6. A recording test apparatus depicts a corresponding signal graph showing the voltage U as a function of time. The time indicia 10-13 on time axis or abscissa t correspond to the points in time during which the water mark moves through the array of the capacitive sensors 11.

To reduce the cross-talk between the sensor channels the evenly numbered control channels 21 and the unevenly numbered control channels 22 are alternatingly energized by a processor. The scanning frequency preferably is 200 kHz.

In a similar presentation, Fig. 6 depicts the signal graph of paper 6, such as a bank note of homogeneously distributed marking substance and provided with a security thread 15, passing through a test device of the kind described above. The signal graph 23 displays a voltage U as a function of time t.

The signal graph 23 depicts a constant voltage of a relatively low level which can be evaluated in respect of those areas of the bank note wherein the marking substance in distributed homogeneously. At the instant in time at which the security thread 15 of higher conductivity moves through the test device, a voltage spike is being registered which differs markedly from the

remaining voltage course. In this manner it is possible to detect the presence of the security thread.

On the basis of a water mark in the embossed area 24, Fig. 7 depicts the testing of electrical conductivity of the paper 6 as a reference test relative to the test of the pictorial structure of the water mark.

The paper 6 with the water mark sequentially moves in the direction of the arrow through an array of optical scanning sensors 10 and a further array of capacitive scanning sensors 11. The associated signal graph depicts the matching voltage course of the optical scanning sensors 10 and of the capacitive scanning sensors 11, shown here as a function of the number of the channels.

Figs. 9 and 10 show the testing of marking substance linearly deposited on paper 6 as well as the signal graphs 23 generated thereby.

In Fig. 9a, paper 6 contains a test zone 14a consisting of marking substance applied in a continuous linear pattern. When passing through the test zone consisting of the optical sensors 13 and the capacitive scanning sensors 11 a corresponding continuous voltage curve U = f(t) is generated in the signal graph 23.

In Fig. 9b the marking substance is applied in an pattern interrupted in regular intervals. During testing, a signal graph 23 is generated with corresponding regular breaks in the voltage curve U = f(t).

In Fig. 9c the application in the test zone 14c is interrupted at irregular intervals. This, too, is reflected in the resulting signal graph 23.

Example 4:

The use of the electrically conductive marking substance in a foil structure to be included in a paper pulp line will hereinafter be explained with reference to Figs. 11 to 14.

The foil structure of the safety element to be included in a paper pulp line contains a support foil 28 made, for instance, of polypropylene, of a thickness of preferably 40 µm. The metallization 29 applied to the support foil 28, for instance, by vapor deposition or sputtering, is of an additional thickness of about 2 nm.

The metallization 29 is provided with demetallized sections shaped, for instance, as letters or numbers, which can be recognized in transmitted light by human vision.

The demetallization extends in sections up to the edge of the support foil 28. At its obverse side the support foil 28 is provided with a further layer 30 made of an electrically conductive polymer. The electrically conductive polymer, for instance, PEDT/PSS (polyethylene dioxythiophene polystyrene sulfonate) based on formula CPP105, is applied to the support foil 28 at a thickness of 1 µm to 2 µm. The addition of the further layer 30 results in a negligible increase in thickness. The foil structure including the marking substance in accordance with the invention included as a security element into the paper pulp line does not, therefore, in any way adversely affect by its insignificantly changed thickness documents or bank notes made from the paper pulp line, even in a stack of considerable height. Neither will the paper be weakened because of its increased thickness at the position where the safety element is embedded.

The metallization 29 applied to the support foil 28 by vapor deposition or sputtering, for instance, has a thickness of a few atomic layers and is thus relatively brittle depending upon the surface structure of the support foil. Folding, bending or creasing leads to arbitrarily distributed hairline fractures

which render impossible any intended measurement of the conductivity of predetermined sections of the metallization 29. The other layer 30, however, is flexible and elastic and, compared to the metallization 29, is of a much higher ductility or expandability with respect to the surface structure of the support foil 28. Even when a bank note, for instance, is bent, creased or folded there will result not interruption or discontinuation of the further layer 30. Hence, the testing devices installed, for instance, in automatic teller machines will now derive for predetermined sections of the security element a value of the conductivity from the metallization 29 provided in accordance with the state of the art, including any possible hairline fractures and from the relatively high-ohmic layer 30 connected in parallel to the metallization 29.

Example 5:

A preferred embodiment of the foil structure including the marking substance for a security element in accordance with the invention, for instance, in a bank note, is depicted in Fig. 11. Fig. 11 depicts the support foil 28 on one side of which there has been applied the metallization 29. The other side of the support foil 28 carries the further layer 30 made of the electrically conductive polymer.

The further layer 30 is applied to the carrier foil 28 by conventional technological processes., for instance, by calendering. This leads to a compound or laminated foil, to which the metallization 29 is subsequently applied as by vapor deposition, for instance.

Of course, it would also be possible to apply the further layer 30 of electrically conductive polymer to the metallization 29 after its vapor deposition on the support foil 28. In such a foil structure, the further layer 30 would bring about a certain protective action in respect of the metallization 29.

Example 6:

Fig. 12 depicts another preferred embodiment of the foil structure including the marking substance in accordance with the invention. The support foil 28 and the metallization 29 are shown. Between the support foil 28 and the metallization 29 the further layer 30 made of the electrically conductive polymer is provided as a bonding agent between support foil 28 and metallization 29. The arrangement of the further layer 30 as a bonding agent is not limited to improving the adhesion between the support foil 28 and metallization 29. The further layer 30 may be applied between any other desired foils or layers for improving their bond. However, used as a bonding agent between the support foil 28 and the metallization 29 results in the advantage that on the substantially more elastic further layer 30 the relatively brittle metallization 29 is capable of withstanding substantially higher mechanical stresses than if vapor deposited directly on the support foil 28.

Example 7:

Fig. 13 depicts a foil structure for a security element including the marking substance in accordance with the invention using a support foil 28 to which the metallization 29 has been applied. The metallization 29 is covered by a further support foil 28'. This is done, for instance, for the protection of the metallization 29 if, with a window thread or strip partially embedded in the paper web, it is subjected to higher stress. Increased stresses during the technological process of paper production are a further reason for the use of t a further support foil 28'. At least one of the support foils 28; 28' is provided with the further layer made from electrically conductive polymer.

Example 8:

In Fig. 13, both support foils 28; 28' are provided with a further layer

30, whereas in Fig. 14 there is shown an embodiment in which only one of the support foils 28 is provided with the further layer 30 of electrically conductive polymer.

Example 9:

Another preferred embodiment consists to provide selected printing inks with the electrically conductive polymer for testing purposes.

The electric conductivity of the polymer may be brought about by different physical processes. One of these processes is based upon the electrically conductive polymer having a particular polymeric grid structure which to some extent permits a shifting of electrons and thus is electrically conductive.

Another physical process consists of adding to the polymer certain minutely distributed substances to cause electrical conductivity. If the starter material selected for the electrically conductive polymer is a substance of a lacquer-like consistency, different additives may be suspended in a fine distribution within the structure of the polymer. In accordance with the invention, these substances may be electrically conductive and thus cause the polymer to become electrically conductive. They may, however, also be of a different kind and may, for instance, contain marking pigments. The certainty against counterfeiting may be further improved by providing further security elements in addition to the electric conductivity, and by combining them appropriately. Thus, in addition to the electrical conductivity of the polymer there may be provided marking pigments perceptible by human vision as well as those which are recognizable only under special light sources and optical sensors. Moreover, the invention extends to the combination of electrical conductivity and additives having magnetic properties. Of particular advantage in the context of the invention is a

combination of electric conductivity and optical and magnetic marking substances. As a preferred application mention may be made of hiding additives with magnetic properties by adding marker pigments which are visible to the human eye. In this manner, a potential counterfeiter will remain uncertain about the presence of a magnetically effective substance, particularly in view of the fact that the quantities used are very low and their magnetic effect cannot be easily detected.

In addition to the mere presence of optically effective additives in the electrically conductive polymer, the invention also extends to arranging the optically effective additives within the electrically conductive polymer in a manner resulting in optical encoding, as, for instance, a dye pattern which may be evaluated by testing devices. The same is applicable to the magnetically effective additives the arrangement in accordance with the invention of which leads to magnetic encoding such as, for instance, a magnetic line code.

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